

A GaAs EQUALIZER-AMPLIFIER FOR 1 Gbit/s DATA TRANSMISSION ON COAXIAL CABLE UP TO 200 METERS

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Abstract

A simple amplitude equalization technique has been applied to coaxial cables to allow binary data transmission up to 1 Gbit/s in a domestic or office environment, where data link length is less than 200 m., and cable installation appears economically advantageous as compared to fiber optic. A new monolithic integrated equalizer-amplifier has been designed to fit to different cable types and lengths by mean of a voltage-controlled equalization.

Introduction

The use of optical fibers for data transmission becomes more and more important for the clear advantages they offer as compared to the electrical cable. Nevertheless there are several applications in which electrical cables are still clearly advantageous, despite of their own limitations, which can be easily overcome.

A bit rate of 1 Gbit/s for a distance around 200 m. is a typical data transmission application that it has been studied in order to find the "best" solution, from the point of view of the overall performances and the related fabrication, installation and maintenance costs.

The performance of a coaxial cable depends on its length, and for a distance larger than 10mt the most used cables show a disequalized attenuation, which makes the output digital pulses to be misleded by a threshold device.

On the other hand there are many situations, in domestic or office environments such as computer local area networks (LAN's) or domestic video facilities, in which different devices must be easily connected to allow high speed data communication.

In some applications characterized by start-stop data transmission between a star connection of talking users an asynchronous transmission apparatus has demonstrated to be suitable for fast time recovering [1]. Such a system requires an RZ codification of the bit stream.

Binary data transmission can be performed adopting either NRZ or RZ data codification, but the bandwidths involved are quite different. As it can be seen in Fig.1, where the waveforms corresponding to a bit sequence in both codification systems are shown, for a bit frequency rate F_0 the NRZ codification requires a channel bandwidth from DC to F_0 , while the RZ codification from F_0 to $2F_0$ [2].

A NRZ transmission system at 0.5 Gb/s using a coaxial cable link has been investigated in this paper. The required channel frequency band is 500 MHz.

Coaxial cable equalization

The attenuation value at 100 MHz and 1 GHz after 100 m. length for some common coaxial cables (Aircom) are listed in Tab.1; in the last line the attenuation slope is reported.

Tab.1 - Coaxial cable attenuations in the 100-1000 MHz band (Aircom)

	units	C-0-8 SAT	C-0-10 SAT	C-0-12 SAT	C-0-22 SAT	RG 58 C/U
100 MHz	dB/100mt	9	5.5	5	6	25
1 GHz	dB/100mt	28	21	19	16	69
slope	dB/dec/100mt	19	15.5	14	10	44

The measured attenuations of the C-0-12 SAT and the RG 58 in the same bandwidth are reported in Fig.2 for a 100 m. long cable.

The attenuation slope changes with cable type and is to be proportional to the cable length. This frequency dependence causes a disequalized waveform to be received after a too long cable. On the other hand, this kind of codification presents an in-band equalization requirement only on the gain magnitude to be really effective at the chosen transmission rate.

A simple magnitude equalizing technique is based on a receiving device with an opposite gain slope, as can be obtained with an RC high-pass filter. If such a device has a gain slope of 20 dB/dec in the specified bandwidth, whatever cable must be no longer than the 20 dB/dec corresponding length. It follows that the gain magnitude equalization should control the slope to be effective with different cable lengths [3].

A new monolithic equalizer-amplifier has been designed with the 0.5 μm GaAs MESFET technology. The circuit, whose schematic is reported in Fig.3, is composed by four decoupled cascaded stages and an output ECL driver [3,4]. The input stage performs power matching with 50 ohm transmission lines. Between the first and the second stage the equalizing circuit is inserted, in which a voltage-controlled FET changes the slope of the transfer function, fitting it to different cable attenuation slopes.

Experimental results

The chip has been fabricated by the Alenia foundry with a $1.9 \times 1.3 \text{ mm}^2$ die size. The microphotograph of the die is shown in Fig.4.

The gain of the equalizer-amplifier for different values of the controlling voltage is plotted in Fig.5. It provides a gain of 24 dB at 1 GHz. The slope sweeps from 3 dB/dec to 16 dB/dec in the 100-1000 MHz band. The slope vs the FET control voltage is plotted in Fig.6. The overall gain flatness, however, of both the cable and the amplifier could be also 5 dB, without affecting the bit error rate.

The equaliser-amplifier has been tested with two available coaxial cables, a 100 m. long C-0-12 SAT and a 42 m. long RG 58, connected together. A bit sequence at 500 Mbit/sec frequency in NRZ mode generated by a Tektronix HFS 9003 pattern generator has been fed into the cables. The output disequalised waveform has been plotted from a HP 54503A digitizing oscilloscope with 500MHz bandwidth. In Fig.7 the input waveform (a) and the output waveform after the cables (b) and the equaliser-amplifier (c) have been plotted. The original bit sequence has been recovered, although inverted, and complementary bit recognition is still allowed [3].

Conclusions

The possibility of fast data transmission up to 1 Gb/s still using commonly available coaxial cables as long as 100 m. has been demonstrated. A new GaAs monolithic equaliser-amplifier has been designed to match different types of cables with different lengths by mean of a voltage-controlled amplitude equalization. A wide range of applications can be found in which equalised coaxial cables perform an efficient link between fast operating devices.

References

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- [4] F.Giannini, E.Limiti, G.Orengo, "A 40 dB single chip pulse amplifier for particle detection", *Proceed. of 26th European Microwave Conference EuMC'96*, p.86, Prague, September 1996.

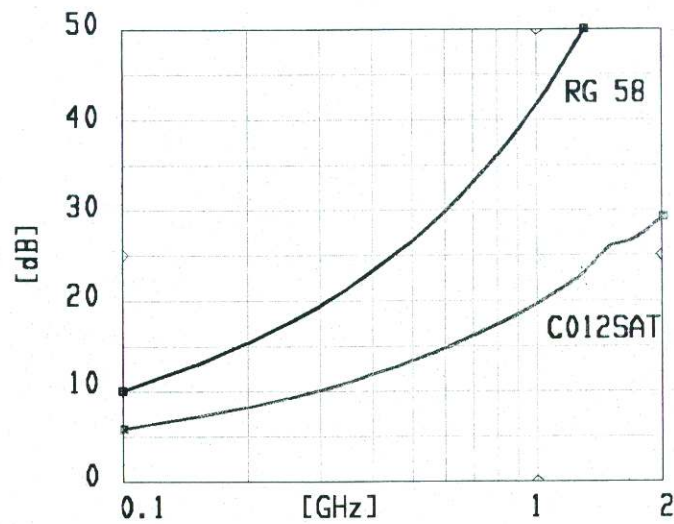


Fig.2. Measured attenuation vs frequency of C-0-12 SAT and RG58 100 m. long coaxial cables.

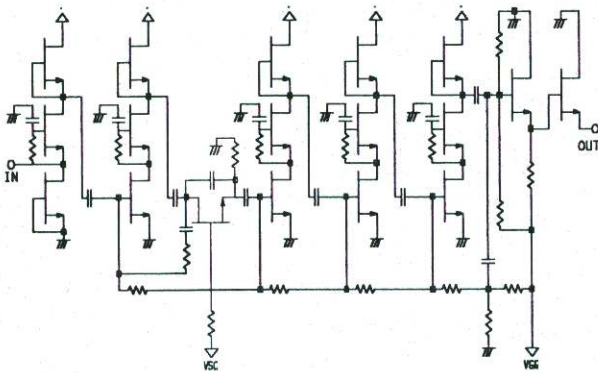


Fig.3. Schematic of the equaliser-amplifier.

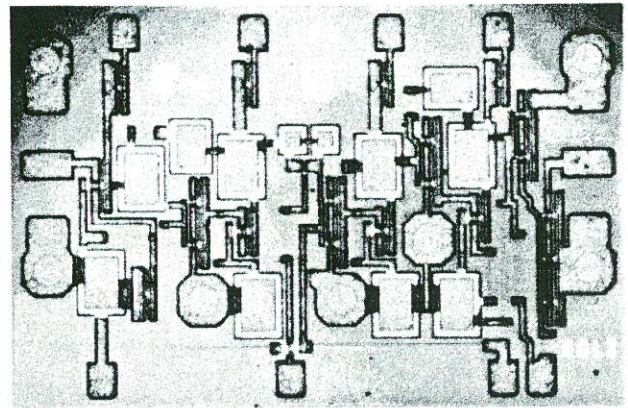


Fig.4. Microphotograph of the equaliser-amplifier (1.9x1.3 mm² die size).

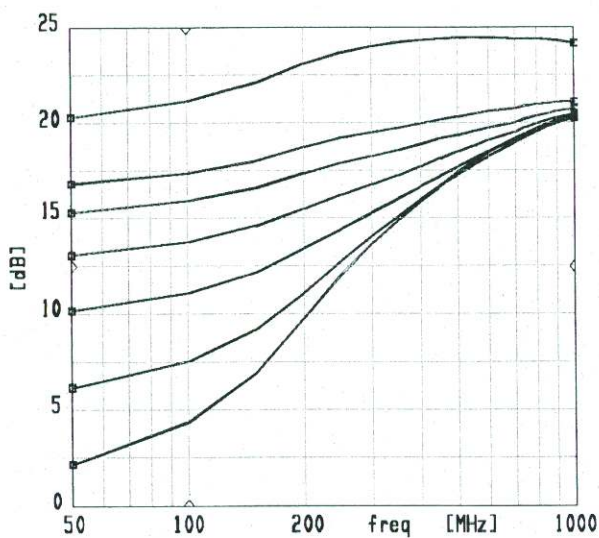


Fig.5. Voltage-controlled gain vs frequency of the equaliser-amplifier

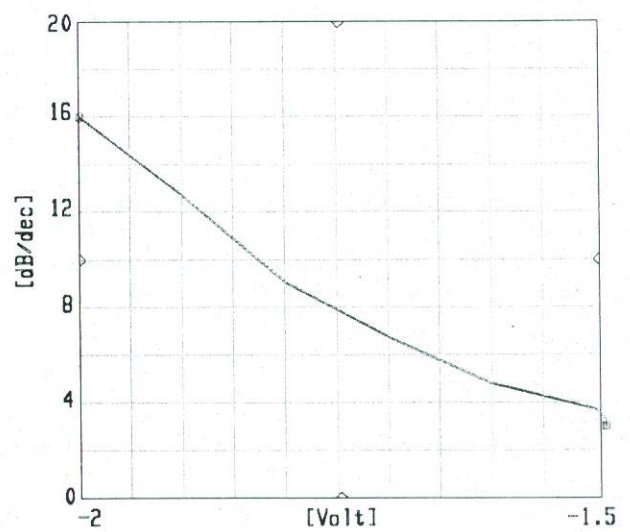
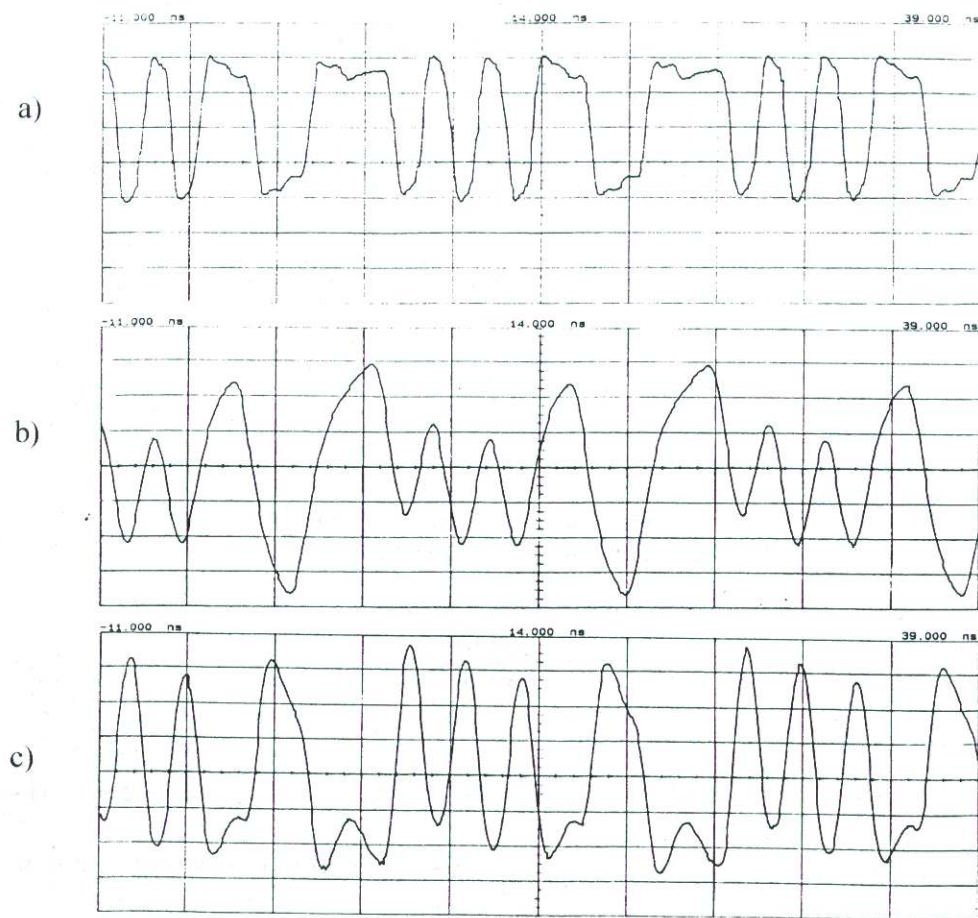


Fig.6. Gain slope variation vs control voltage of the equalising stage.



Timebase 5 ns/div

Sensitivity 30 mV/div

Fig.7. a) Input waveform for a 500 Mb/s NRZ bit stream from a Tektronix HFS 9003 pattern generator. b) Output waveform after 100m. of C-0-12 SAT plus 42 m. of RG58 coaxial cable. c) Output waveform after the equaliser-amplifier.